ORGANIZATIONAL INSTRUCTION

RELIABILITY ANALYSIS

OPR(s)	**OPR DESIGNEE**
QD10, QD20, QD30 and QD40	**Prince Kalia**

DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Baseline		11/20/97	
Revision	A	11/22/99	Changes made to reflect new organization code changes and/or Changes made to reflect new directives renumbering scheme and to incorporate the corrective action for closure of NCR 266. Change completes OWI to OI conversion.
Revision	B	07/01/01	Changed OPR and OPR Designee. Added Quality Records table.
Revision	C	9/09/02	Format and numbering change to implement requirements of QS-A-001 rev F.
Revision	D	10/21/03	Added applicable and reference documents. Added additional Reliability Analysis details.
Revision	E	10/1/04	Updated OI to implement HQ Rules Review in accordance with CAITS Action # 04-DA-01-0387) (Utilizing the word "Shall" for all requirements, removing ambiguity, removing non-requirements, etc.)

Reliability Analysis

1.   PURPOSE, SCOPE, APPLICABILITY

1.1 <u>Purpose</u>

The purpose of this Organizational Instruction (OI) is to provide procedures on various analysis tools that shall be used for assessing system reliability during the different program phases.

1.2 <u>Scope</u>

This OI describes the S&MA responsibility that shall be performed for flight hardware/software for reliability analysis. Reliability analysis is the process of evaluating reliability during the life cycle of a system using probabilistic risk assessment models, reliability predictions, Failure Modes And Effects Analysis/Critical Items Lists (FMEA/CILs), reliability assessment, reliability trade studies and sensitivity analyses, demonstrated reliability models, trend analysis, and reliability growth models.

1.3   <u>Applicability</u>

This OI shall be applicable to all S&MA personnel supporting MSFC programs and projects that require or specify reliability requirements.

2. DOCUMENTS (Applicable and/or Referenced)

2.1   <u>Applicable Documents</u>

NPD 8720.1   NASA Reliability and Maintainability (R&M) Program Policy

NASA-STD-8729.1   Planning, Developing and Managing an Effective Reliability and
                              Maintainability (R&M) Program

MPG 8730.4   Statistical Techniques

2.2. <u>Reference Documents</u>

MIL-HDBK-189   Reliability Growth Management

QD-R-001   Failure Mode and Effects Analysis and Critical Items List

QD-R-009   Reliability Prediction

Handbook of Reliability Engineering and Management, W.G. Ireson and C.F. Coombs Jr., 1988.

Probabilistic Risk Assessment and Management for Engineers and Scientists, H. Kumamoto and E.J. Henley, 1996.

Reliability Toolkit: A Practical Guide for Commercial Products and Military Systems Under Acquisition Reform, Reliability Analysis Center

3. DEFINITIONS

All definitions applicable to this OI are addressed in NASA-STD-8729.1

4. INSTRUCTIONS

An example of a typical Reliability analysis process is shown in Figure 1. The following sections provide an overview of different types of reliability analyses (probabilistic risk assessment, demonstrated reliability, trend analysis, and reliability growth). The analyses shall be updated as appropriate (i.e., with design changes or design evolution).

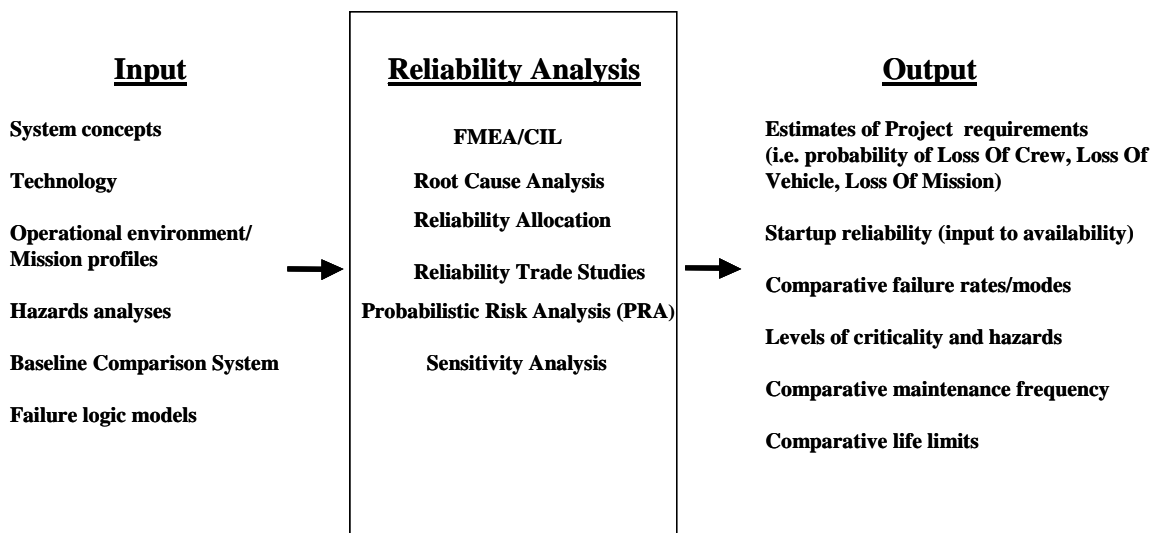| **Input**	**Reliability Analysis**	**Output**
System concepts	**FMEA/CIL**	**Estimates of Project requirements (i.e. probability of Loss Of Crew, Loss Of Vehicle, Loss Of Mission)**
Technology	**Root Cause Analysis**	
	Reliability Allocation	
Operational environment/ Mission profiles		**Startup reliability (input to availability)**
	Reliability Trade Studies	
Hazards analyses	**Probabilistic Risk Analysis (PRA)**	**Comparative failure rates/modes**
Baseline Comparison System	**Sensitivity Analysis**	**Levels of criticality and hazards**
		Comparative maintenance frequency
Failure logic models		**Comparative life limits**

Figure 1. Reliability Analysis Flow Process

4.1 Probabilistic Risk Assessment

A Probabilistic Risk Assessment (PRA) shall be performed to calculate risk, perform sensitivity analysis, and conduct trade studies at various system levels. The steps below define the procedure for developing a probabilistic risk assessment model and are referenced in the Flow Diagram 4.1 in Section 11.

Steps	Action
4.1.1	Define the system for which the probabilistic risk assessment is applicable and the baseline design assumptions for which the

reliability analysis is anchored.
Also, identify reliability design criteria. Describe analysis approach and expected tools to be utilized.

4.1.2   Collect/screen and analyze data.

4.1.3   Identify initiating events and underlying assumptions.

4.1.4   Construct event sequence diagrams (ESDs) for each initiating event.

4.1.5   Determine the uncertainty distribution for each initiating and pivotal events and rationale for selection.

4.1.6   Aggregate the uncertainty distributions in 4.1.5.

4.1.7   Aggregate all ESDs results to determine the risk for failure mode/component/system/ subsystem.

4.1.8   Report results and identify potential updates.

4.2   Reliability Prediction

When a limited amount of data is available, reliability predictions shall be performed, in lieu of PRA, to calculate risk, perform sensitivity analysis, and conduct trade studies. Refer to Organizational Instruction QD-R-009 for more information regarding Reliability Prediction.

4.3   Failure Modes and Effects Analysis/Critical Items List

The Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) provides a qualitative method to identify single failure points and effects and to establish and rank critical failures for purposes of potential design improvements at component and/or system level. Maximum benefit results from application early in the design process. Refer to Organizational Instruction QD-R-001 for more information regarding FMEA/CIL.

4.4   Demonstrated Reliability Determination

Reliability demonstration provides a quantitative estimate of reliability based on objective data. For maximum benefit, it shall be focused on appropriately tailoring test inputs to produce the data needed to anchor reliability analyses. The steps below define the procedure for performing reliability demonstration and are referenced in the Flow Diagram 4.2 in Section 11.

Steps	Action
4.4.1	Define the item to be considered for reliability demonstration.

Define reliability test objective, parameters, and preferred data format.

4.4.2   Collect applicable objective data (e.g. actual test/flight data).

4.4.3   Identify the appropriate reliability model (e.g. binomial, weibull, etc.) and methods for selection. Identify tools used.

4.4.4   Determine the demonstrated reliability prediction for the item under consideration.

4.4.5   Publish technical results and recommendations. Update when needed.

4.5   Trend Analysis

Trend analysis is a tool that shall be used in conjunction with reliability analysis. The steps below define the procedure for performing trending analysis and are referenced in the Flow Diagram 4.3 contained in Section 11.

Steps	Action
4.5.1	Identify the item/parameter to be trended.
4.5.2	Identify and collect applicable data.
4.5.3	Identify appropriate trending technique.
4.5.4	Perform trend analysis.
4.5.5	Interpret trend data and identify trends and underlying assumptions.
4.5.6	Publish technical results and recommendations.

4.6   Reliability Growth

Reliability growth processes and tools shall be used to help improve system reliability due to changes in product design or the manufacturing process. Reliability growth studies usually have two objectives. The first objective is the determination of demonstrated reliability at some point in time. The second objective provides information about growth patterns that might be useful to support decisions regarding the future of the program. This process shall provide flexibility to allow continuous feedback into the design process; such as identifying process benchmarks to check actual against predictions, so that adjustments can be made that shall allow a return to

schedule with minimal program impact. The steps below define the procedure for performing reliability growth analysis and are referenced in the Flow Diagram in Section 11.

Steps	Action
4.6.1	Identify the item to be considered for reliability growth analysis.
4.6.2	Establish a system by which test/flight data are collected and maintained.
4.6.3	Determine the appropriate reliability growth model (example: Army Materials System Activity Analysis (AMSAA)) Identify reliability test parameters to be tracked with design evolution.
4.6.4	Perform reliability growth analysis to track item reliability over time and provide roadmaps to address expected design deltas.
4.6.5	Assess reliability growth analysis results to determine reliability trend.
4.6.6	Establish dynamic reliability growth model to accommodate potential design changes.

5.   NOTES

5.1   Directive Replacement. This Directive replaces S&MA-CR10-R-Y-010, Reliability Analysis.

5.2   Records

Records	Repository	Period of Time
Reliability Analysis Report shall be retained per program requirements	Hardcopy maintained in R&M files in Building 4471 Room A105	Retain until end of program plus 3 years.

6.   SAFETY PRECAUTIONS AND WARNING NOTES

None.

7.   APPENDICES, DATA, REPORTS, AND FORMS

None.

8.   RECORDS

None

9. TOOLS, EQUIPMENT, AND MATERIALS

The user shall define any tools, special equipment, or materials used during the reliability analysis process.

10. PERSONNEL TRAINING AND CERTIFICATION

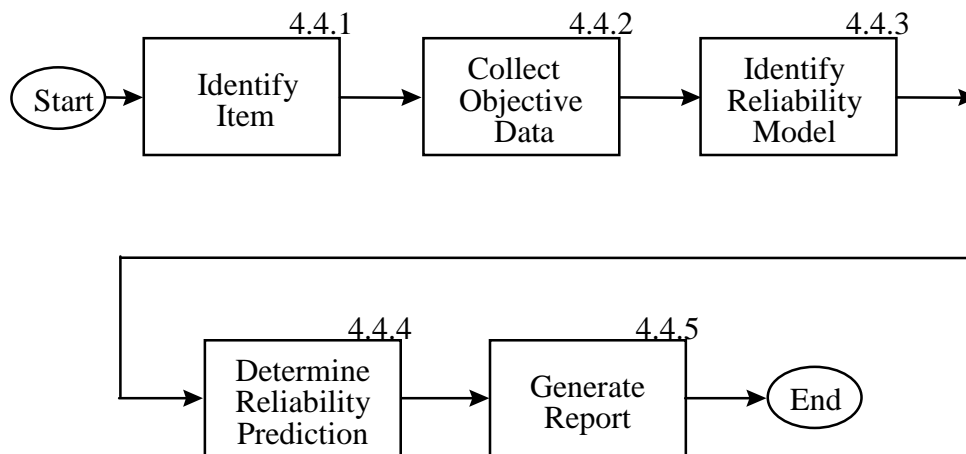Reliability training shall include reliability analysis.

11. FLOW DIAGRAM

The following flow diagram represents the Reliability Analysis instructions for Probabilistic Risk Assessment outlined in Section 4.1.
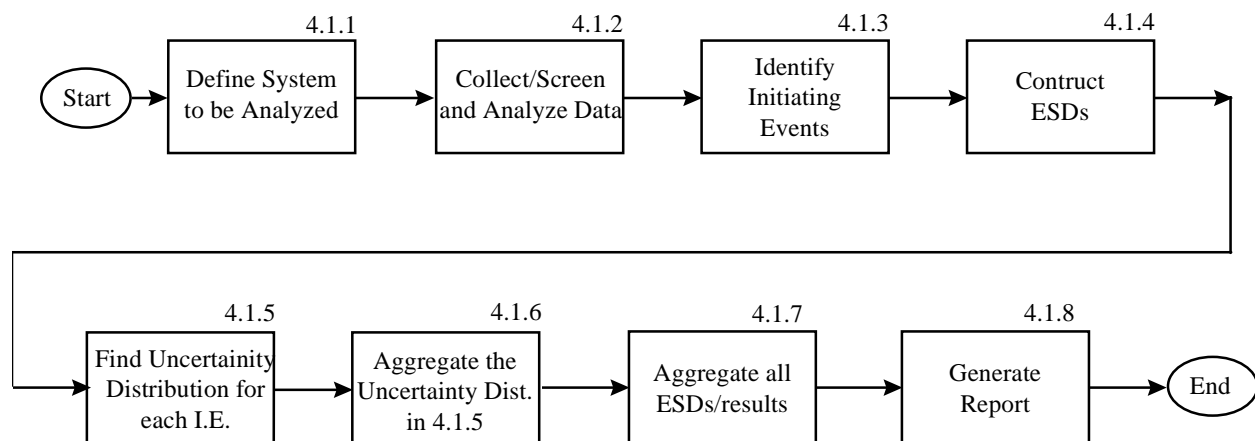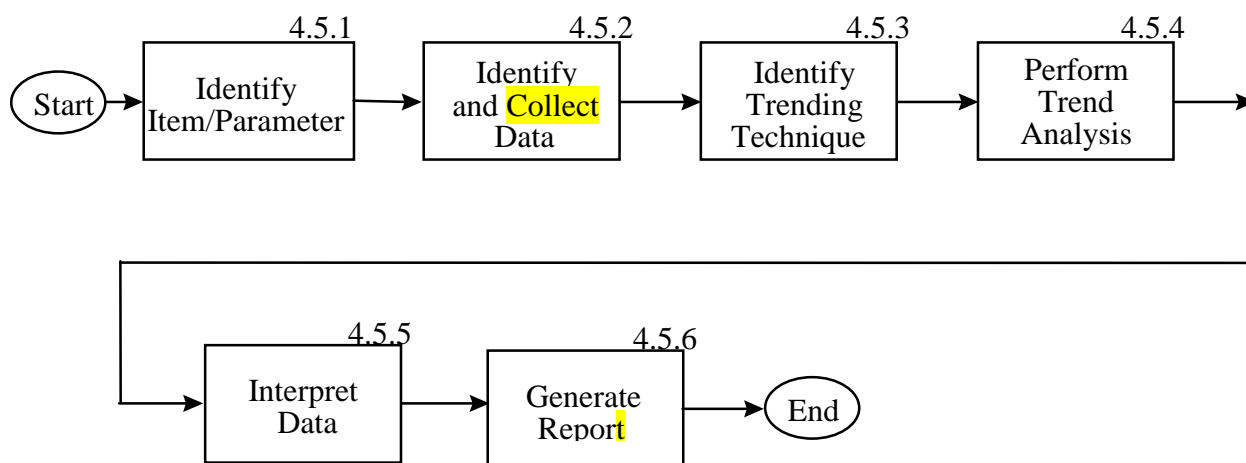

The following flow diagram represents the Reliability Analysis instructions for Reliability Demonstration outlined in Section 4.4.

4.4.1   4.4.2   4.4.3

Start → Identify Item → Collect Objective Data → Identify Reliability Model →

4.4.4   4.4.5

→ Determine Reliability Prediction → Generate Report → End

The following flow diagram represents the Reliability Analysis instructions for Trending Analysis outlined in Section 4.5.

4.5.1   4.5.2   4.5.3   4.5.4

Start → Identify Item/Parameter → Identify and Collect Data → Identify Trending Technique → Perform Trend Analysis →

4.5.5   4.5.6

→ Interpret Data → Generate Report → End

The following flow diagram represents the Reliability Analysis instructions for Reliability Growth outlined in Section 4.6.

4.6.1

(Start) → [Identify Item] → 4.6.2 [Establish System to Collect Data] → 4.6.3 [Determine Reliability Growth] → 4.6.4 [Perform Reliability Growth] →

4.6.5 [Assess Results] → 4.6.6 [Generate Report] → (End)